at higher risk of developing post-traumatic OA. Patient reported outcomes from the Multicenter Orthopaedic Outcomes Network (MOON) prospective longitudinal cohort of over 1500 patients undergoing ACL reconstruction showed no increase in OA symptoms (KOOS) at 2 or 6 years after surgery. Therefore, identification of structural changes of OA that may precede the onset of symptoms is of critical importance for determining risk factors for the initiation and progression of post-traumatic OA in addition to measuring the effectiveness of potential disease-modifying treatments. One such structural measure of OA is radiographic joint space width (JSW). The purpose of this study was thus to examine whether JSW differences are evident in an onsite cohort of patients 2 years after ACL reconstruction, and to determine what factors predict more difference in JSW between ACL reconstructed and contralateral normal knees.

Methods: 256 patients from the MOON cohort (111 males, 145 females, mean age 20 years, range 12 - 33 at surgery) were recruited at a minimum of 2 years following surgery for on-site evaluations including bilateral fixed flexion radiographs to assess JSW. (See table 1) To minimize bias related to pre-existing knee injury or OA, subjects were 35 years or younger, were injured playing a sport, had primary ACL reconstruction without prior meniscus or articular cartilage surgery, did not undergo subsequent ACL revision, and had a surgically normal contralateral knee. Radiographic JSW was measured in the medial compartment of both knees using a validated method to measure minimum JSW (mJSW). The association of age, gender, BMI, meniscus treatment, and articular cartilage treatment with mJSW differences (JSD) between the reconstructed and normal knees was examined using multivariable generalized linear models.

Results: The mean medial compartment mJSW was 5.03 ± 0.78 mm for ACL reconstructed and 4.70 ± 0.74 mm for contralateral normal knees ($p < 0.001$). See Table 2 for stratified analyses of JSD by graft source, medial meniscus treatment, and medial femoral condyle cartilage status. A multivariable generalized linear model was constructed which adjusted for age, gender, BMI, and baseline Marx activity level. Predictors of increased JSD that were statistically significant included increased age ($p < 0.001$), meniscus resection ($p < 0.001$) and meniscus repair ($p = 0.003$).

Conclusions: We found that radiographic mJSW differences between reconstructed and normal knees could be detected 2 years after surgery in a cohort of patients with previously uninjured knees who sustained ACL tears and underwent subsequent ACL reconstruction. JSD was greater in older patients and in knees that had partial medial meniscectomy or repairs. There was no significant difference based on articular cartilage status. Interestingly, the overall average medial JSW was increased in the reconstructed knees compared to the normal knees, which may represent a swelling effect of articular cartilage in the earliest stages of post-traumatic OA, and warrants further investigation.

Table 1
Characteristics of the cohort

n	256
Males	111 (43.3%)
Age	20.1 year (SD 4.98)
BMI	23.6 (SD 3.67)
Graft source	
Bone-Patellar Tendon-Bane	162 (62.9%)
Hamstrings	85 (33.2%)
Allograft	9 (3.9%)
Medical meniscus treatment	
No tear	152 (59.4%)
Tear, no treatment	28 (10.9%)
Repair	52 (20.3%)
Partial meniscectomy	24 (9.4%)
Medial femoral condyle articular cartilage status	
Normal	230 (89.8%)
Grade I	3 (1.2%)
Grade II	19 (7.4%)
Grade III	1 (0.4%)
Grade IV	3 (1.2%)

Table 2. Results stratified by graft source, medial meniscus treatment, and cartilage status. Joint Space Difference (JSD) indicates (mJSW in the normal knee) – (mJSW in the reconstructed knee)

Parameter	JSD mean ± SD	P-value
Graft source		
Bone-Patellar Tendon-Bone	−0.38 ± 0.55 mm	P = 0.13
Hamstrings	−0.22 ± 0.83 mm	
Allograft	−0.47 ± 0.62 mm	
Medial meniscus treatment		
No tear	−0.46 ± 0.55 mm	P < 0.001
Tear, no treatment	−0.47 ± 0.44 mm	
Repair	−0.18 ± 0.75 mm	
Partial meniscectomy	0.32 ± 0.85 mm	
Medial femoral condyle articular cartilage status		
Normal / Grade I	−0.35 ± 0.65 mm	P = 0.086
Grade II-IV	−0.11 ± 0.76 mm	

433
KNEE PAIN AND INFLAMMATION IN THE INFRAPATELLAR FAT PAD ESTIMATED BY CONVENTIONAL AND DYNAMIC CONTRAST-ENHANCED MAGNETIC RESONANCE IMAGING IN OBESE PATIENTS WITH OSTEOARTHRITIS: A CROSS-SECTIONAL STUDY

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Purpose: To investigate the association between knee pain and signs of inflammation in the infrapatellar fat pad (IPFP) in obese patients with knee osteoarthritis (KOA).

Methods: In a cross-sectional setting, 3-Tesla conventional contrast-enhanced (CE) magnetic resonance imaging (MRI) and dynamic contrast-enhanced (DCE)-MRI of KOA were analysed to quantify the extent of inflammation in the IPFP and correlated to self-reported outcomes on pain, symptoms and quality of life assessed via the Knee injury and Osteoarthritis Outcome Score (KOOS). Data were from a weight-loss maintenance study in obese KOA patients - the LIGHT study, including patients ≥50 years of age with a body mass index (BMI) ≥30 kg/m^2, and clinical KOA verified on radiographs. Our study included all patients attending the recall at the 1-year visit. The extent of inflammation in the IPFP was assessed according to the MOAKS (MRI Osteoarthritis Knee Score) recommendations using CE-MRI and by DCE-MRI perfusion variables, analysed by use of the computer software program Dynamika® (Image analysis Ltd, London). A region of interest (ROI) was drawn around the IPFP on the axial DCE-MR images from the apex of the patella to the insertion of the patellar tendon on the tibia. For each voxel within the ROI, signal intensity versus time curves were extracted and automatically assigned to one of four patterns of contrast uptake: i) "no enhancement", ii) "persistent", iii) "plateau" or iv) "washout". "No enhancement" and "persistent" are usually seen in disease-unaffected tissues, whereas "plateau" is typical for tissues with higher perfusion, and "washout" for blood vessels and severely inflamed tissues. From the time intensity curves and contrast models, maximal enhancement (ME), showing the intensity increase over the baseline of the curve, and initial rate of enhancement (IRE), showing the increase in signal intensity per second until maximum enhancement is reached, were automatically calculated. The highest values for IRE and ME were shown in bright yellow and lower values in a spectrum towards red colours (Fig.). The following perfusion variables were determined: Σ IRE x (N-plateau + N-washout) ("Inflammation"), Σ ME x (N-plateau + N-washout), N-plateau + N-washout, volume of the IPFP, and "Inflammation" divided by the volume of the IPFP. The perfusion variable "Inflammation" was chosen as the primary perfusion variable in the analysis. IRE is known to correlate with the grade of histological synovial inflammation and N-plateau + N-washout are the voxels with pathological enhancement patterns. Intraclass correlation coefficients for the perfusion variables ranged from 0.81–0.99.

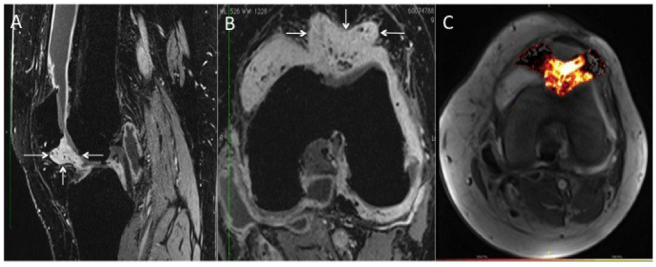

Fig. 1. Hoffa-synovitts (MOAKS grade 3). Arrows encapsulate the enhancing lesions of various grades (A+B). A and B. Sagittal and axial knee gradient echo (GRE) T1-weighted (T1w) VIBE post-contrast MRI. C. Axial DCE-MRI GRE T1w VIBE sequence. Changes in signal intensity after Gadolinium injection are shown for the region of interest (ROI), the infrapatellar fat pad. Voxels are colour-coded for Initial rate of enhancement (IRE).

Results: MRI and clinical data were obtained in 95 patients. The typical patient participating in this study was a 65-year old woman with a body mass index (BMI) of 32 kg/m^2. The bivariate association between KOOS pain and each of the DCE-MRI perfusion variables showed statistically significant correlations: Σ IRE x (N-plateau + N-washout) ("Inflammation") ($r = -0.42$, $p < 0.0001$), Σ ME x (N-plateau+N-washout) ($r = -0.43$, $p < 0.0001$), N-plateau + N-washout ($r = -0.43$, $p < 0.0001$), volume of the IPFP ($r = -0.39$, $p = 0.0001$), and "Inflammation" divided by the volume of the IPFP ($r = -0.37$, $p = 0.0002$). A statistically significant correlation was also seen between KOOS pain and MOAKS Hoffa-synovitis ($r = -0.21$, $p = 0.046$).
Conclusions: Perfusion variables on DCE-MRI reflecting inflammation in the IPFP and MOAKS Hoffa-synovitis were associated with knee pain in obese KOA patients. These results suggest that severe inflammation in the IPFP is associated with severe pain in KOA and that DCE-MRI is a robust and promising method to study the impact of inflammation in KOA.

434
SUBREGIONAL KNEE CARTILAGE THINNING OR THICKENING IS AGE-DEPENDENT AND IS ASSOCIATED WITH SERUM BIOMARKERS IN ADOLESCENT AND MATURE VOLLEYBALL ATHLETES

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Purpose: Cartilage structural change caused by aging, training or disease can be accurately and directly measured using MRI; while biomarker quantification from serum may be helpful in characterizing or predicting cartilage maturation. Cartilage Oligomeric Matrix Protein (COMP) represents an established serum biomarker of cartilage turnover, whereas Cartilage Intermediate Layer Protein (CILP) is a novel biomarker that is thought to be associated with cartilage degradation. In the current study we investigated whether MRI-based cartilage thinning and thickening in young and mature athletes is related to baseline or concurrent change in COMP and CILP levels
Methods: Twenty adolescent (baseline age 16.0 ± 0.6 y) and 20 mature (46.3 ± 4.7 y) volleyball athletes were studied (10 men, 10 women). MR images (3D VIBE) and serum markers were obtained at baseline (BL) and at 2-year follow-up (Y2). Cartilage thickness was measured in 16 femorotibial subregions (8 medial, 8 lateral, 10 tibial, 6 femoral). Femorotibial subregional cartilage thinning (ThCTnS) and thickening (ThCTkS) scores were computed, by summarizing in each subject the BL → Y2 changes across all subregions with thinning and thickening, respectively. Further, a cartilage change score (ThCChS) was computed by summarizing the magnitudes of all subregional changes, independent of direction. COMP was analyzed using the commercial sandwich COMP ELISA (AnaMar AB) and CILP with an in-house research competitive immunoassay (AnaMar AB). Unpaired t-tests were used to compare results between female and male participants, paired t-tests to test whether change from BL → Y2 was significant, and linear regression to analyze the correlation between serum and imaging markers
Results: Data on COMP and MRI was available in 18 mature (9 men, 9 women) and 12 adolescent athletes (9 men, 3 women); data on CILP and MRI was available in 15 mature (7 men, 8 women) and 8 adolescent athletes (6 men, 2 women) (Table 1). There was no indication of significant differences (defined by $p \leq 0.05$) in serum or imaging markers between men and women in mature ($p > 0.31$) or adolescent athletes ($p > 0.17$). The mature athletes displayed much higher subregional cartilage thinning than thickening scores, and the adolescent athletes much higher thickening than thinning scores, whereas the non-directional change scores were similar in mature and adolescent participants (Table 1). Pooled analyses in both sexes suggested a significant increase in CILP ($p = 0.02$) for BL → Y2 in mature athletes, but no significant change in COMP ($p = 0.63$). Similar relationships were observed in adolescent athletes ($p = 0.009$ for CILP, and 0.88 for COMP). In mature adults, BL → Y2 COMP change was negatively correlated with BL COMP ($r = -0.62$; $p < 0.01$, CI: −0.32, −0.84), and BL → Y2 CILP change was negatively correlated with BL CILP ($r = -0.73$; $p < 0.01$, CI: −0.53, −0.87). Neither BL COMP and CILP, nor BL → Y2 COMP and CILP changes were significantly correlated with each other ($p = 0.06$ and $p = 0.13$, respectively). BL COMP and BL CILP levels were not significantly associated with subregional cartilage thinning, thickening, or the non-directional change score ($p \geq 0.19$). BL → Y2 change in COMP was not significantly associated with BL → Y2 change in imaging markers. However, the association between BL → Y2 change in CILP and that in non-directional change score was significant ($r = 0.48$; $p < 0.05$). Very similar observations were made in adolescent athletes (e.g.: $r = -0.52$; $p = 0.08$ for BL → Y2 CILP change vs. non-directional subregional cartilage thickness change), but these associations did not reach statistical significance, given the much smaller sample size.
Conclusions: This study compares subregional MRI-based cartilage thickness change, with baseline values and longitudinal change in two serum biomarkers (COMP and CILP). The above cartilage change scores are particularly useful in correlation analyses with serum biomarkers, because they describe structural tissue change in each direction (thinning and thickening) at a subregional level. A limitation of this study is the small sample size, in particular in the group of the adolescent athletes. Further, the study was exploratory and did not correct for multiple statistical testing. Nevertheless, our results indicate that longitudinal change in CILP and COMP are negatively correlated to BL values, and that change in CILP (but not change in COMP; nor BL CILP or COMP) is concurrently associated with subregional cartilage change.

Baseline (BL) values and longitudinal changes from BL to 2-year follow-up (Y2) in COMP and CILP

	Mature athletes		Adolescent athletes	
	Women	Men	Girls	Boys
BL COMP	12.6 ± 3.9	13.1 ± 4.3	11.6 ± 4.5	16.5 ± 5.1
Change COMP	0.2 ± 2.57	0.67 ± 4.87	-0.85 ± 6.17	0.03 ± 3.75
BL CILP	1.72 ± 1.11	1.16 ± 1.05	0.59 ± 0.48	0.62 ± 0.57
Change CILP	0.70 ± 1.79	1.64 ± 1.97	2.41 ± 1.25	0.70 ± 0.95
ThCTnS (mm)	−0.40 ± 0.17	−0.52 ± 0.42	-0.10 ± 0.10	−0.22 ± 0.20
ThCTkS (mm)	0.15 ± 0.17	0.12 ± 0.10	0.47 ± 0.21	0.67 ± 0.74
ThCChS (mm)	0.55 ± 0.11	0.65 ± 0.37	0.57 ± 0.21	0.89 ± 0.61

435
CAN T2 PREDICT WHO WILL DEVELOP ROA? DATA FROM THE OAI

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Purpose: Knee OA has a substantive impact on quality of life and its early detection is essential for development of efficient interventions. Radiological MRI scores of cartilage damage have shown some predictive power in detecting which subjects may develop radiological OA as defined by KL scores. Further, T2 weighted imaging has been routinely used to detect cartilage lesions. The purpose of this study was to 1) evaluate whether the cartilage T2-relaxation-parameters are different at the time of detection of radiological OA (ROA) in the incidence